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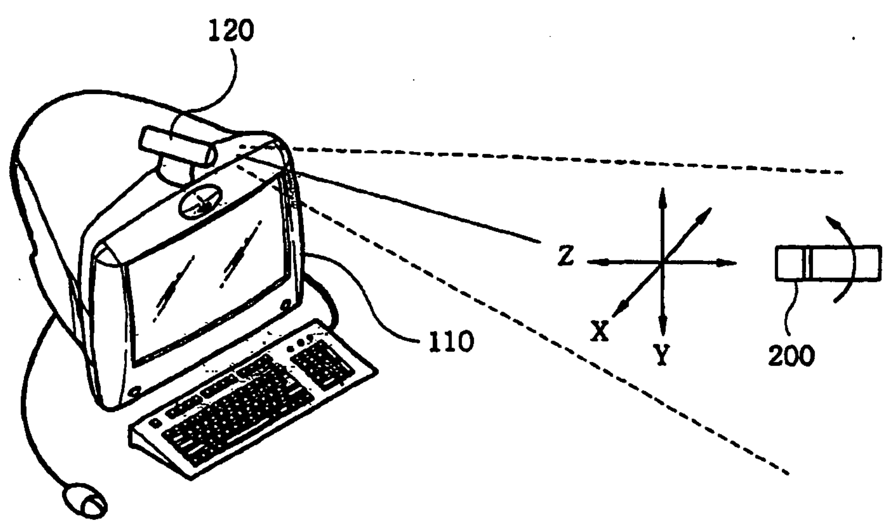
[Continued on next page]

(54) Title: MOTION MOUSE SYSTEM



(57) Abstract: An apparatus for inputting three-dimensional movements and status information includes a motion mouse having at least one indicator showing the status information, which is arranged on a first surface of the motion mouse, and at least one control switch for controlling a status of the indicator, which is arranged on a second surface of the motion mouse, a camera for capturing an image of the motion mouse and an image analyzer for analyzing the image of the motion mouse by using the lens formula to recognize the three-dimensional movements and the status information of the motion mouse. The indicators may have different color, size or shape from each other to effectively represent a rotational movement of the motion mouse. The apparatus inputs three-dimensional movements of the motion mouse in a simple and cost-effective manner without transmitting/receiving any data between a computer and a pointing device through wire or wireless connection.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

MOTION MOUSE SYSTEM

Technical Field

The present invention relates to an apparatus and a method for inputting three-dimensional coordinates and status information of a pointing device into an information device such as a computer; and, more particularly, to an apparatus and a method for analyzing an image obtained by capturing a movement of a pointing device in a three-dimensional space and recognizing changes of three-dimensional coordinates and status information of the pointing device.

Background Art

Generally, as a pointing device for positioning a cursor on a display screen of a computer, a device called "mouse" has been used. Such a pointing device detects its relative displacement over a plane by employing an optical method or a mechanical method for detecting a movement of a ball installed inside the pointing device. The detected displacement is converted into a displacement of the cursor on the display screen. However, since the mouse is designed to move along a two-dimensional plane, it has a limitation that three-dimensional movements of the mouse cannot be

transferred to the computer.

Meanwhile, as users of personal computers or CAD (computer aided design) systems require a device for inputting positions and shapes of various three-dimensional objects, a variety of pointing devices for inputting three-dimensional coordinates have been proposed. Such three-dimensional pointing devices may have a function to measure its movement along the z-axis in addition to its two-dimensional movement over the x-y coordinate system. Further, the three-dimensional pointing devices may employ an accelerometer for detecting its rotating movement along the x, y and z axes.

However, the prior art pointing device may cause its user inconvenience since the pointing device may need a supplementary device such as a supporting board on which the pointing device moves. Further, the prior art three-dimensional pointing device has to be located within a short distance from a computer when they are wire-connected to each other. If the pointing device is wireless-connected to the computer through, e.g., IR (infrared) light, the limitation of distance between the pointing device and the computer may be overcome. Even in this case, however, if an IR light emitting direction of one side, e.g., the pointing device, does not coincide with an IR light reception direction of the other side, e.g., the computer, data communications between the both sides may be interrupted.

Disclosure of Invention

It is, therefore, an object of the present invention to provide an apparatus and a method for analyzing an image obtained by capturing a movement of a pointing device in a three-dimensional space in front of a computer and recognizing changes of three-dimensional coordinates and status information of the pointing device.

In accordance with one aspect of the present invention, there is provided an apparatus for inputting three-dimensional coordinates and status information of a motion mouse, including: the motion mouse including more than one indicator, which are arranged on a first surface of the motion mouse, for representing the status information and more than one control switch, which are arranged on a second surface of the motion mouse, for controlling the status information represented by the indicators; a camera for capturing images of the indicators arranged on the first surface; and an image analyzer for analyzing the captured images and recognizing three-dimensional coordinates and status information of the motion mouse.

In accordance with another aspect of the present invention, there is provided a method for inputting three-dimensional coordinates and status information of a motion mouse including more than one indicator, which are arranged on a first surface of the motion mouse, for representing the

status information and more than one control switch, which are arranged on a second surface of the motion mouse, for controlling the status information represented by the indicators, the method including the steps of: capturing images of the indicators; extracting areas of the indicators by using information on colors, sizes and/or shapes of the indicators or locations of the indicators on the first surface; determining center coordinates of the areas of the indicators; and determining changes of three-dimensional positions, an amount of rotation and status information of the motion mouse by using the determined center coordinates.

Brief Description of Drawings

The above and other objects and features of the present invention will become apparent from the following description of preferred embodiments given in conjunction with the accompanying drawings, in which:

Fig. 1 sets forth an apparatus for inputting three-dimensional coordinates and status information of a motion mouse in accordance with a preferred embodiment of the present invention;

Fig. 2 depicts a motion mouse in accordance with a preferred embodiment of the present invention;

Fig. 3 illustrates a rotation of a front surface of a motion mouse in accordance with a preferred embodiment of

the present invention, the front surface having two illuminators thereon;

Fig. 4 provides a flowchart showing a method for inputting three-dimensional coordinates and status information of a motion mouse in accordance with a preferred embodiment of the present invention;

Fig. 5 presents a diagram of a lens and an object for describing the concept of the lens formula; and

Fig. 6 charts a rotation of a front surface of a motion mouse in accordance with a preferred embodiment of the present invention and changes of locations of illuminators attached on the front surface in accordance with the rotation of the front surface.

Best Mode for Carrying Out the Invention

Referring to Fig. 1, there is provided a configuration of an apparatus for inputting three-dimensional coordinates and status information of a motion mouse in accordance with a preferred embodiment of the present invention. As shown in Fig. 1, the apparatus includes a computer 110, a camera 120 for capturing an image, which is connected to the computer 110, a pointing device (hereinafter referred to as "motion mouse") for representing three-dimensional positions and status information. A user of the computer 110 represents three-dimensional positions and status

information by moving the motion mouse 200 in a three-dimensional space in front of the camera 120. The camera 120 captures images of the movements of the motion mouse 200, such that an analysis software executed in the computer 110 analyzes the images captured by the camera 120 to recognize the three-dimensional positions and the status information of the motion mouse 200.

Herein, since the motion mouse 200 does not have to transceive any information through a wired or wireless connection, the motion mouse 200 can move freely in a three-dimensional space in front of the camera 120. For instance, the motion mouse 200 may rotate or move in left/right and up/down directions or any combination thereof. The rotational movement of the motion mouse 200 may be decomposed into several rotational components on x, y and z axes (the z axis represents an axis passing through a center of a lens, i.e., angle of view, of the camera 120.)

Fig. 2 illustrates a configuration of the motion mouse 200 in accordance with a preferred embodiment of the present invention. The motion mouse 200 includes a plurality of illuminators 211 to 213 and a plurality of switches 221 to 223 for controlling ON/OFF status of the illuminators 211 to 213. The switches 221 to 223 respectively control flickering of the illuminators 211 to 213, so that a combination of the ON/OFF status of the illuminators 211 to 213 represents status information such as

selection/cancellation of a specific function, scrolling of a computer screen and three-dimensional movements of the motion mouse 200.

Although the illuminators 211 to 213 have been described to be arranged in a line on the front surface of the motion mouse 200 in Fig. 2, the illuminators 211 to 213 may be arranged asymmetrically with respect to a center of the front surface of the motion mouse 200. When the illuminators 211 to 213 are arranged asymmetrically with respect to the center of the front surface of the motion mouse 200, the motion mouse 200 can represent any rotational movements. Further, as shown in Fig. 2, even when the illuminators 211 to 213 are arranged symmetrically with respect to the center of the front surface of the motion mouse 200, the illuminators 211 to 213 may be configured to have different sizes, shapes and/or colors. The number of the illuminators may be varied as long as the motion mouse can represent various three-dimensional movements.

Fig. 3 charts an exemplary image of a front surface of the motion mouse 200, which is captured by the camera 120. In Fig. 3, the motion mouse 200 employs two illuminators L1 and L2, each of which has a different size. In this case, although the motion mouse 200 has only two illuminators L1 and L2, the motion mouse 200 can represent various rotational movements.

In general, the illuminators 211 to 213 may be

designed to emit visible rays. Alternatively, in order to perform more rapidly and precisely analysis of an image captured by the camera 120, the illuminators 211 to 213 may be implemented to irradiate infrared rays. In this case, an infrared filter may be installed in front of the camera 120 to filter the infrared rays emitted by the illuminators 211 to 213. The illuminators 211 to 213 need a power supply, which is installed inside the motion mouse 200 or the computer 110, to produce the rays. However, the illuminators 211 to 213 may be implemented by using fluorescent materials, which eliminate any needs for the power supply. In order to easily distinguish one of the illuminators from one another, the illuminators 211 to 213 may have different sizes, shapes and/or colors (or frequencies). Further, there may be installed shutters in front of the illuminators 211 to 213 to replace the flickering (i.e., ON/OFF) functions of the illuminators 211 to 213. In this case, the control switches 221 to 223 are configured to control the opening and shutting movements of the shutters.

In the meantime, analysis software is executed inside the computer 110 for analyzing images of the motion mouse 200, which are captured by the camera 120. In the following, a method for analyzing the images of the motion mouse in accordance with a preferred embodiment of the present invention will be described in detail with reference to Fig.

4.

First, the camera 120 captures the movements of the motion mouse 200 and transfers the captured images of the motion mouse 200 to the computer 110 (step 402). Then, the analysis software, which is executed in the computer 110, performs analysis of the captured images.

The analysis software extracts areas of the illuminators in the images of the motion mouse 200 (step 404). The analysis software may preprocess the images to easily extract the areas of the illuminators from the images. For example, a threshold value may be predetermined to convert pixel levels of the images into binary values, i.e., 0 and 1, such that, when a pixel level of the images is larger than or equal to the threshold value, a high level, e.g., 1, is assigned to the pixel. Further, when the pixel level is smaller than the threshold value, a low level, e.g., 0, is assigned to the pixel. Meanwhile, the computer 110 stores information on locations, colors, sizes and/or shapes of the illuminators arranged on the front surface of the motion mouse 200, which is utilized by the analysis software to extract more precisely the areas of the illuminators.

Thereafter, center coordinates of the extracted areas of the illuminators are calculated (step 406). The center coordinates of the extracted areas may be set to, e.g., centroids of the areas.

The analysis software then reckons amounts of

forward/backward, right/left, up/down movements or rotations of the motion mouse 200 based on the center coordinates of the illuminators and the distances between the center coordinates (step 410). Herein, the analysis software utilizes the lens formula in calculating changes in positions of the motion mouse 200 on the z axis. For instance, as shown in Fig. 5, if it is assumed that a distance between an object *O* and a lens 510, a distance between an image *I* and the lens 510 and a focal distance of the lens 510 are *b*, *a* and *f*, respectively, a mathematical expression ("the lens formula") as shown in Equation (1) can be formulated.

$$\frac{1}{a}+\frac{1}{b}=\frac{1}{f} \qquad \text{Equation (1)}$$

In this case, a magnification *m* of the lens 510 can be determined as expressed in Equation (2).

$$m=\frac{b}{a}=\frac{H}{h} \qquad \text{Equation (2)}$$

Therefore, the analysis software determines the magnification *m* by measuring a distance (i.e., the size *H* of the object) between the illuminators of the motion mouse 200 and a pixel distance (i.e., the size *h* of the image) between

the center coordinates of the illuminators. Further, the analysis software estimates the distance *b* by using the fixed distance *a* in accordance with Equation (2). Accordingly, by measuring changes of the pixel distance (i.e., the size *h* of the image) between the center coordinates of the illuminators, changes in the positions of the illuminators on the z axis can be calculated.

Meanwhile, the amounts of rotations of the motion mouse 200 on the x, y and z axes may be calculated by measuring changes in the positions of the illuminators and the distances between the positions. For instance, as illustrated in Fig. 6, wherein four illuminators *L1* to *L4* having different shapes or colors are arranged crosswise with respect to a center *C* on the front surface of the motion mouse 200, a coordinate (Δx, Δy) of the center *C* on the x-y plane with respect to the z axis (*O*) and the amount ($\Delta\theta$) of rotations of the illuminators *L1* to *L4* may be estimated. Further, by measuring changes in a ratio of a distance between the illuminators *L1* and *L3* and that between the illuminators *L2* and *L4*, the amount of rotation of the motion mouse 200 with respect to the x axis or the y axis can be determined.

The analysis software recognizes ON/OFF status or brightness of the illuminators while calculating changes of the positions of the illuminators (step 408). And then, the ON/OFF status or brightness of the illuminators is converted

into information on selection/cancellation of specific functions or scrolling of a display screen.

The determined three-dimensional positions and status information of the motion mouse 200 are then stored in a memory of the computer 110 to be provided for an application program (step 412). The application program may be a browser program for navigating in a three-dimensional space composed by using three-dimensional graphics technology or a CAD program for editing three-dimensional objects. Although the method of the present invention has been described to be executed by software installed in the computer 110, a part or all of the steps of the method may be executed by an ad hoc hardware.

As described above, the method and apparatus for inputting three-dimensional coordinates and status information of a motion mouse in accordance with the present invention transfers changes of the three-dimensional coordinates and status information of the motion mouse without performing wireless or wired data transmission between the motion mouse and the computer. Therefore, the method and apparatus of the present invention have an advantage that a user can input three-dimensional movements of a pointing device more intuitively. These aspects of the present invention contribute to convenience and portability of a pointing device.

While the invention has been shown and described with

respect to the preferred embodiments, it will be understood by those skilled in the art that various changes and modifications may be made without departing from the spirit and scope of the invention as defined in the following claims.

CLAIMS

1. An apparatus for inputting three-dimensional coordinates and status information of a motion mouse, comprising:

the motion mouse including more than one indicator, which are arranged on a first surface of the motion mouse, for representing the status information and more than one control switch, which are arranged on a second surface of the motion mouse, for controlling the status information represented by the indicators;

a camera for capturing images of the indicators arranged on the first surface; and

an image analyzer for analyzing the captured images and recognizing three-dimensional coordinates and status information of the motion mouse.

2. The apparatus of claim 1, wherein the indicators are illuminators, which are switchable ON or OFF, and each of the control switches controls the ON/OFF of the corresponding illuminator.

3. The apparatus of claim 2, wherein the illuminators emit infrared lights and the camera includes a filter for filtering the infrared lights.

4. The apparatus of claim 2, wherein the illuminators have different colors, sizes and/or shapes.

5. The apparatus of claim 2, wherein the illuminators are arranged asymmetrically with respect to a center of the first surface.

6. The apparatus of claim 1, wherein the motion mouse further includes shutters for opening and shutting the indicators, wherein the indicators have different colors, sizes and/or shapes and the control switches control the opening and shutting of the shutters.

7. The apparatus of claim 6, wherein the illuminators are arranged asymmetrically with respect to a center of the first surface.

8. The apparatus of claim 1, wherein the image analyzer performs the steps of:

determining center coordinates of the indicators;

calculating pixel distances between the center coordinates; and

calculating changes in three-dimensional positions and an amount of rotation of the indicators by using the pixel distances and the lens formula.

9. The apparatus of claim 8, wherein the image analyzer analyzes the captured images to determine ON/OFF status, colors, sizes and/or shapes of the indicators, thereby determining the status information of the motion mouse.

10. A method for inputting three-dimensional coordinates and status information of a motion mouse including more than one indicator, which are arranged on a first surface of the motion mouse, for representing the status information and more than one control switch, which are arranged on a second surface of the motion mouse, for controlling the status information represented by the indicators, the method comprising the steps of:

capturing images of the indicators;

extracting areas of the indicators by using information on colors, sizes and/or shapes of the indicators or locations of the indicators on the first surface;

determining center coordinates of the areas of the indicators; and

determining changes of three-dimensional positions, an amount of rotation and status information of the motion mouse by using the determined center coordinates.

11. The method of claim 10, wherein the step of determining changes of the three-dimensional positions includes the steps of:

calculating pixel distances between the center coordinates; and

calculating changes in three-dimensional positions and an amount of rotation of the indicators by using the pixel distances and the lens formula.

12. The method of claim 11, wherein the step of determining changes in the three-dimensional positions further includes a step of analyzing the captured images to determine ON/OFF status, colors, sizes and/or shapes of the indicators, thereby determining the status information of the motion mouse.

AMENDED CLAIMS

Received by the International bureau on 19 August 2003 (19.08.03); original claims 1 and 6 have been replaced by the amended claims. Claim 4 has been cancelled.

1. An apparatus for inputting three-dimensional coordinates and status information of a motion mouse, comprising:

the motion mouse including more than one indicator, which are arranged on a first surface of the motion mouse, for representing the status information and more than one control switch, which are arranged on a second surface of the motion mouse, for controlling the status information represented by the indicators, wherein the indicators have different colors, sizes and/or shapes;

a camera for capturing images of the indicators arranged on the first surface; and

an image analyzer for analyzing the captured images and recognizing three-dimensional coordinates and status information of the motion mouse.

2. The apparatus of claim 1, wherein the indicators are illuminators, which are switchable ON or OFF, and each of the control switches controls the ON/OFF of the corresponding illuminator.

3. The apparatus of claim 2, wherein the illuminators emit infrared lights and the camera includes a filter for filtering the infrared lights.

4. (Cancelled)

5. The apparatus of claim 2, wherein the illuminators are arranged asymmetrically with respect to a center of the first surface.

6. The apparatus of claim 1, wherein the motion mouse further includes shutters for opening and shutting the indicators, wherein the control switches control the opening and shutting of the shutters.

7. The apparatus of claim 6, wherein the illuminators are arranged asymmetrically with respect to a center of the first surface.

8. The apparatus of claim 1, wherein the image analyzer performs the steps of:

determining center coordinates of the indicators;

calculating pixel distances between the center coordinates; and

calculating changes in three-dimensional positions and an amount of rotation of the indicators by using the pixel distances and the lens formula.

9. The apparatus of claim 8, wherein the image analyzer

analyzes the captured images to determine ON/OFF status, colors, sizes and/or shapes of the indicators, thereby determining the status information of the motion mouse.

10. A method for inputting three-dimensional coordinates and status information of a motion mouse including more than one indicator, which are arranged on a first surface of the motion mouse, for representing the status information and more than one control switch, which are arranged on a second surface of the motion mouse, for controlling the status information represented by the indicators, the method comprising the steps of:

capturing images of the indicators;

extracting areas of the indicators by using information on colors, sizes and/or shapes of the indicators or locations of the indicators on the first surface;

determining center coordinates of the areas of the indicators; and

determining changes of three-dimensional positions, an amount of rotation and status information of the motion mouse by using the determined center coordinates.

11. The method of claim 10, wherein the step of determining changes of the three-dimensional positions includes the steps of:

calculating pixel distances between the center

coordinates; and

calculating changes in three-dimensional positions and an amount of rotation of the indicators by using the pixel distances and the lens formula.

12. The method of claim 11, wherein the step of determining changes in the three-dimensional positions further includes a step of analyzing the captured images to determine ON/OFF status, colors, sizes and/or shapes of the indicators, thereby determining the status information of the motion mouse.

FIG.1

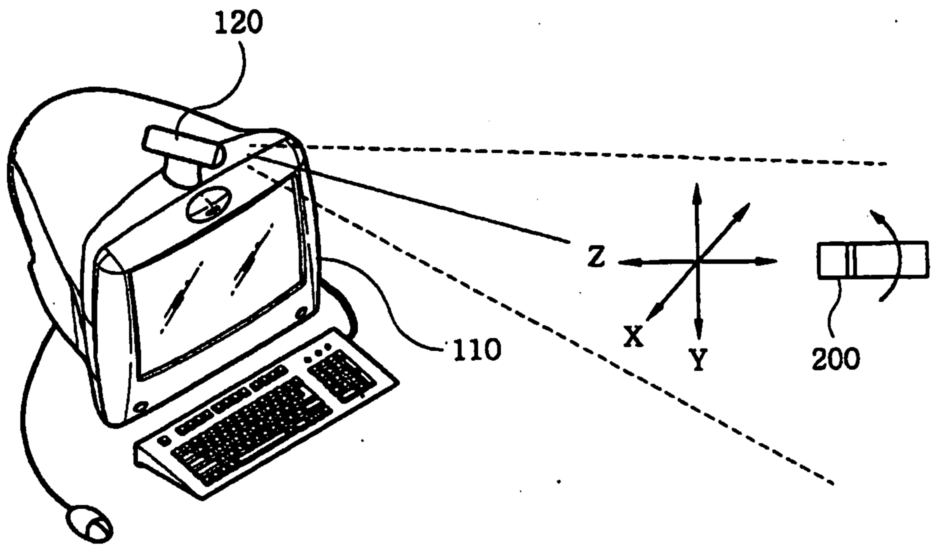


FIG.2

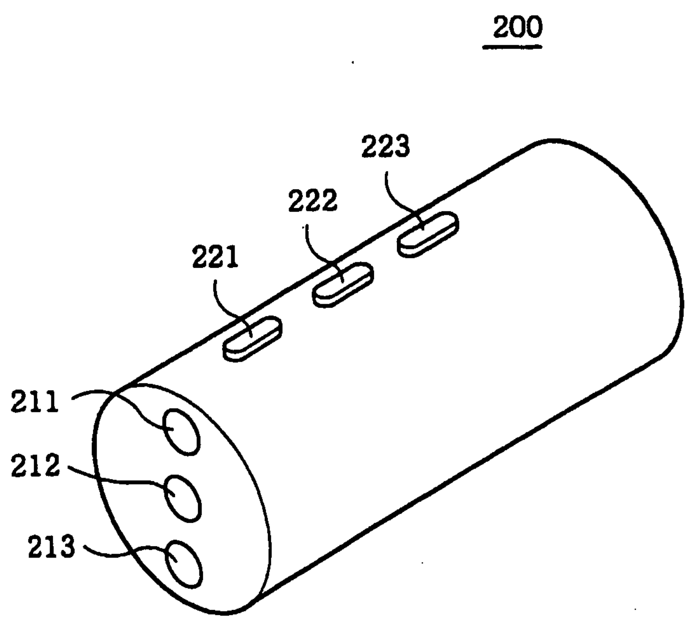


FIG.3

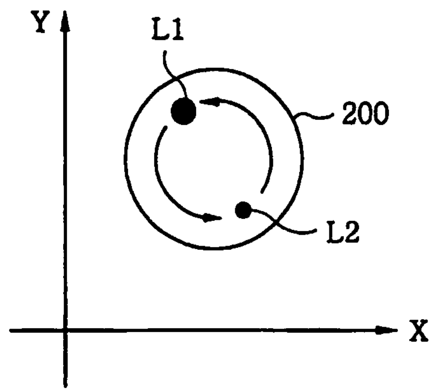

Y
L1
200
L2
X

FIG.4

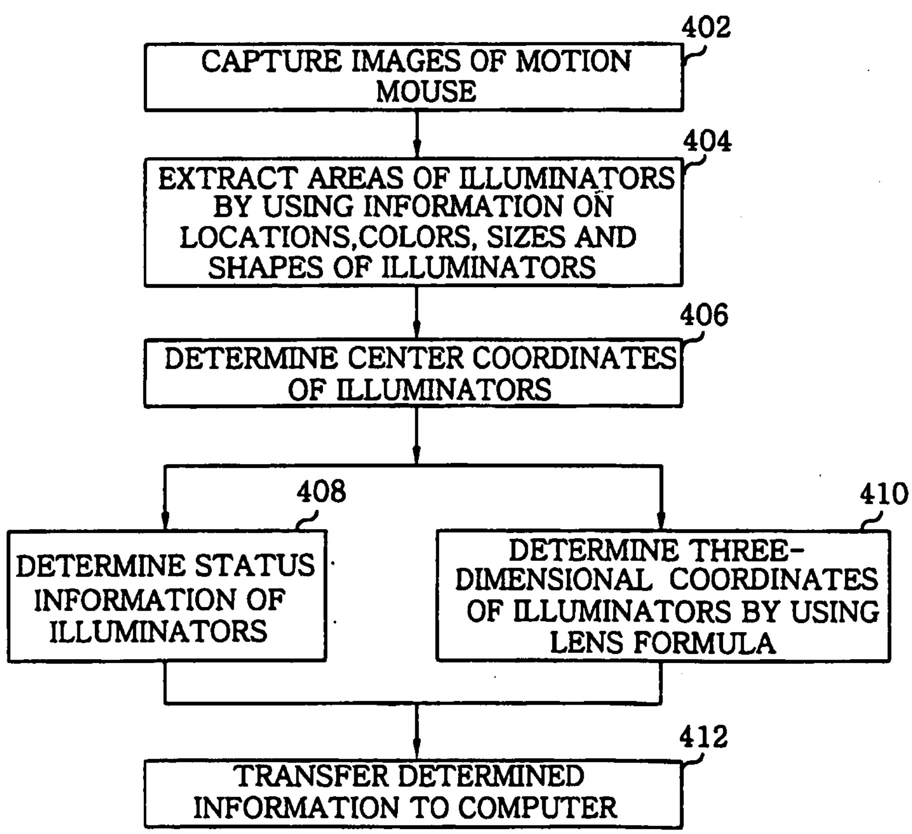

402
CAPTURE IMAGES OF MOTION MOUSE
404
EXTRACT AREAS OF ILLUMINATORS BY USING INFORMATION ON LOCATIONS,COLORS, SIZES AND SHAPES OF ILLUMINATORS
406
DETERMINE CENTER COORDINATES OF ILLUMINATORS
408
DETERMINE STATUS INFORMATION OF ILLUMINATORS
410
DETERMINE THREE-DIMENSIONAL COORDINATES OF ILLUMINATORS BY USING LENS FORMULA
412
TRANSFER DETERMINED INFORMATION TO COMPUTER

FIG.5

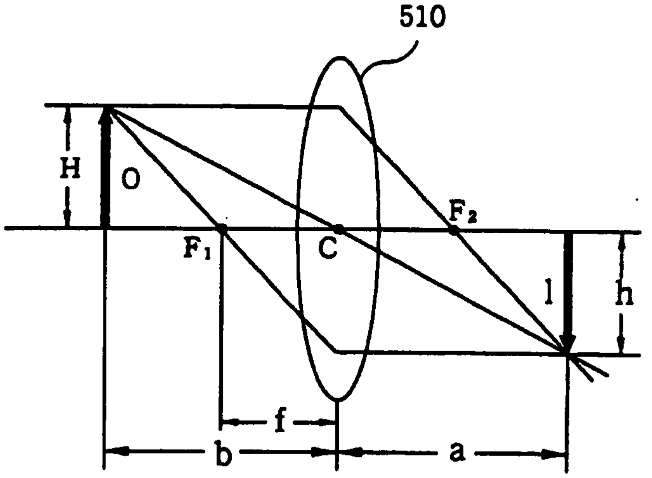
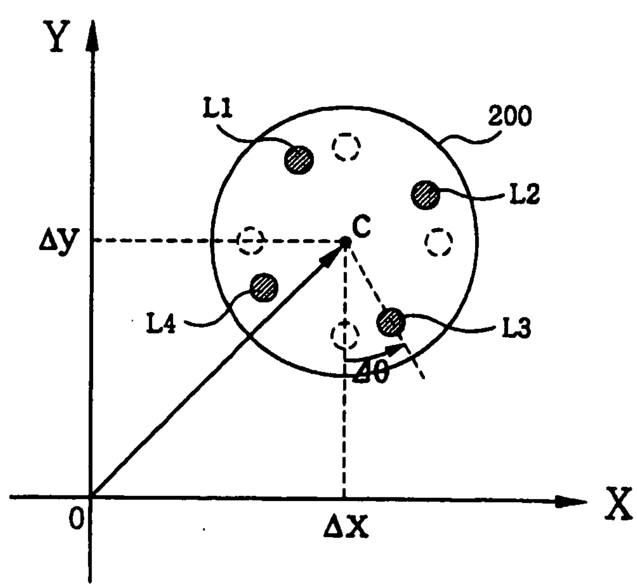


FIG.6



INTERNATIONAL SEARCH REPORT

International application No.
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A. CLASSIFICATION OF SUBJECT MATTER

IPC7 G06F 3/033

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC G06F 1/, GO6F3/

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean Patents and applications for invetions since 1975
Korean Utility models and applications for Utility models since 1975

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search terms used)

KIPASS, PAJ, FPD, USPTO, DELPION

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,297,061 A (University of Maryland) 22, Mar, 1994 see abstract and claim 1	1-2, 4-12
Y	JP 2001-60141 A (CANON INC) 6, Mar, 2001 see abstract and clains 1, 16	1-2, 4-12
A	JP 1997(09)-265346 (BIJIYUARU SCI KENKYOSHO) 7, Oct, 1997 see from 4 page 36 to 5 page 41	1-12
A	JP 1997(09)-34633 (SANYO ELECTRIC LTD) 7, Feb, 1997 see claims 1 , 2	1-12

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 JUNE 2003 (17.06.2003)	19 JUNE 2003 (19.06.2003)

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